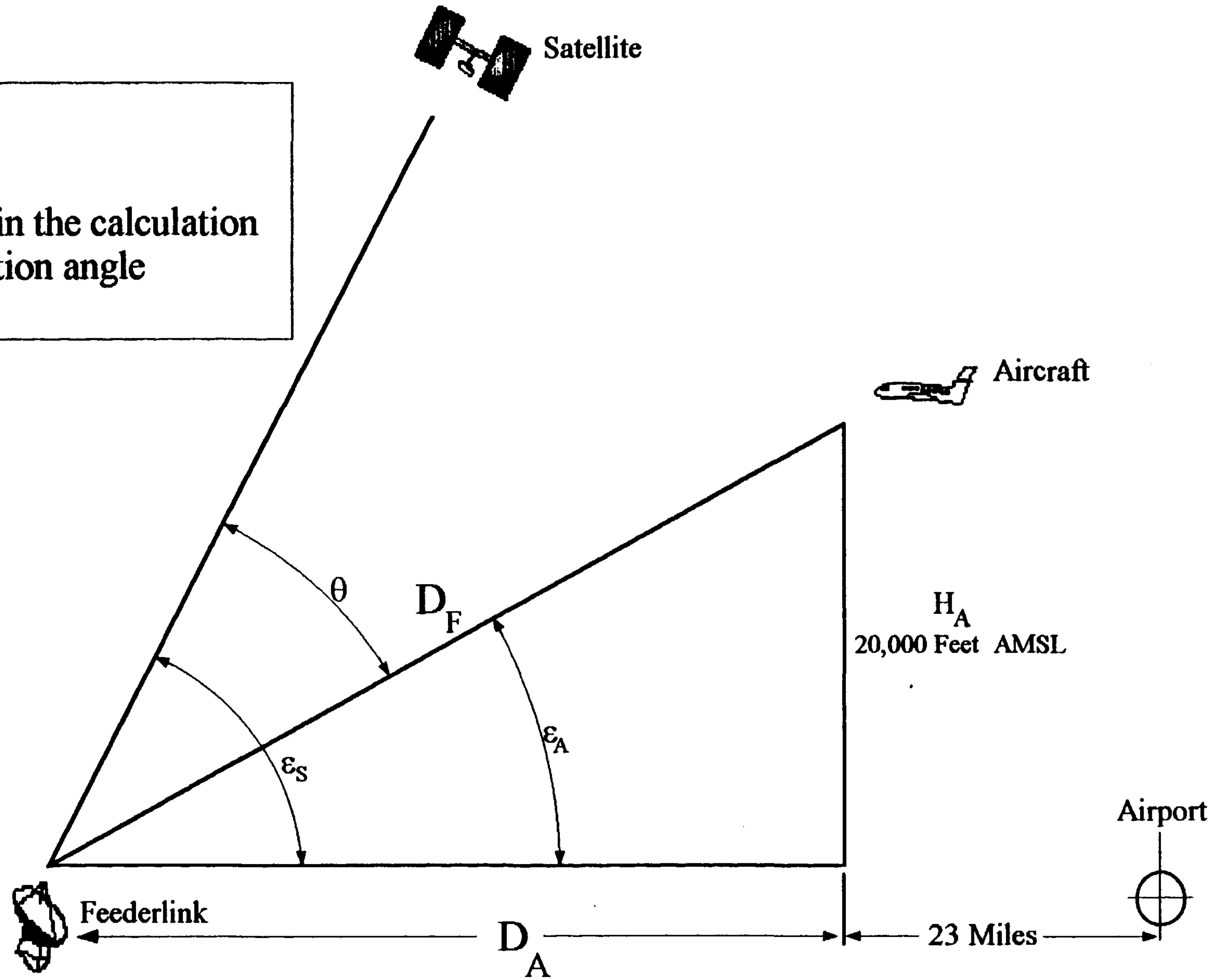


Figure 3.1-6

Parameters used in the calculation of the discrimination angle

Table 3.1-11 shows the interference power given by Equation (1-3) and in accordance with Figure 3.1-5 for the four typical airports.

TABLE 3.1-11

Interference Level at Aircraft with OH Losses

	DCA	MGW	PIT	PSK
D_A distance aircraft	64.83	69.47	124.83	132.68
P_F (dBW/4 kHz)	-16	-16	-16	-16
ϵ_A elevation angle to aircraft (degrees)	3.34	3.12	1.73	1.64
θ discrimination angle (degrees)	6.66	6.88	8.27	8.36
GF_A (dBi)	11.41	11.06	9.06	8.94
FSL (dB)	147.04	147.63	152.72	153.26
I_R (dBW/4 kHz)	-151.63	-152.57	-159.66	-160.32
OH losses for 80 percent of the time (dB)	28.36	0	28.63	0
I_A dBW/4 kHz	-179.98	-152.57	-188.29	-160.32
Interference Objective (dBW/4 kHz)	-165.74	-165.74	-165.74	-165.74
Interference Objective - I_A (dB)	14.24	-13.17	22.55	-5.42

In Table 3.1-11, I_A is the interference level into the aircraft when over-the-horizon losses are considered. For the Washington DCA location there were sufficient O-H losses to provide an objective to interference margin of 14.24 dB. Therefore, the direct path from Williamsville is not a potential interference case.

An aircraft approaching Pittsburgh (PIT) airport would not be affected by the Williamsville uplink as the interfering signal is 22.55 dB below the objective.

Aircraft approaching either the Morgantown (MGW) or Dublin (PSK) airports are line-of-sight. Morgantown (MGW) and Dublin (PSK) margins are -13.17 dB and -5.42 dB respectively. The margins reflect potential interference. The Dublin airport site is located 155 miles from Williamsville and is a potential interference case since line-of-sight conditions exist.

For the Washington (DCA) airport where minimum blockage appeared to exist, seven different profiles were constructed. Figure 3.1-7 shows the areas to where the profiles were constructed. These profiles were evaluated to provide a more accurate assessment of the interference potential for the various aircraft locations when approaching DCA.

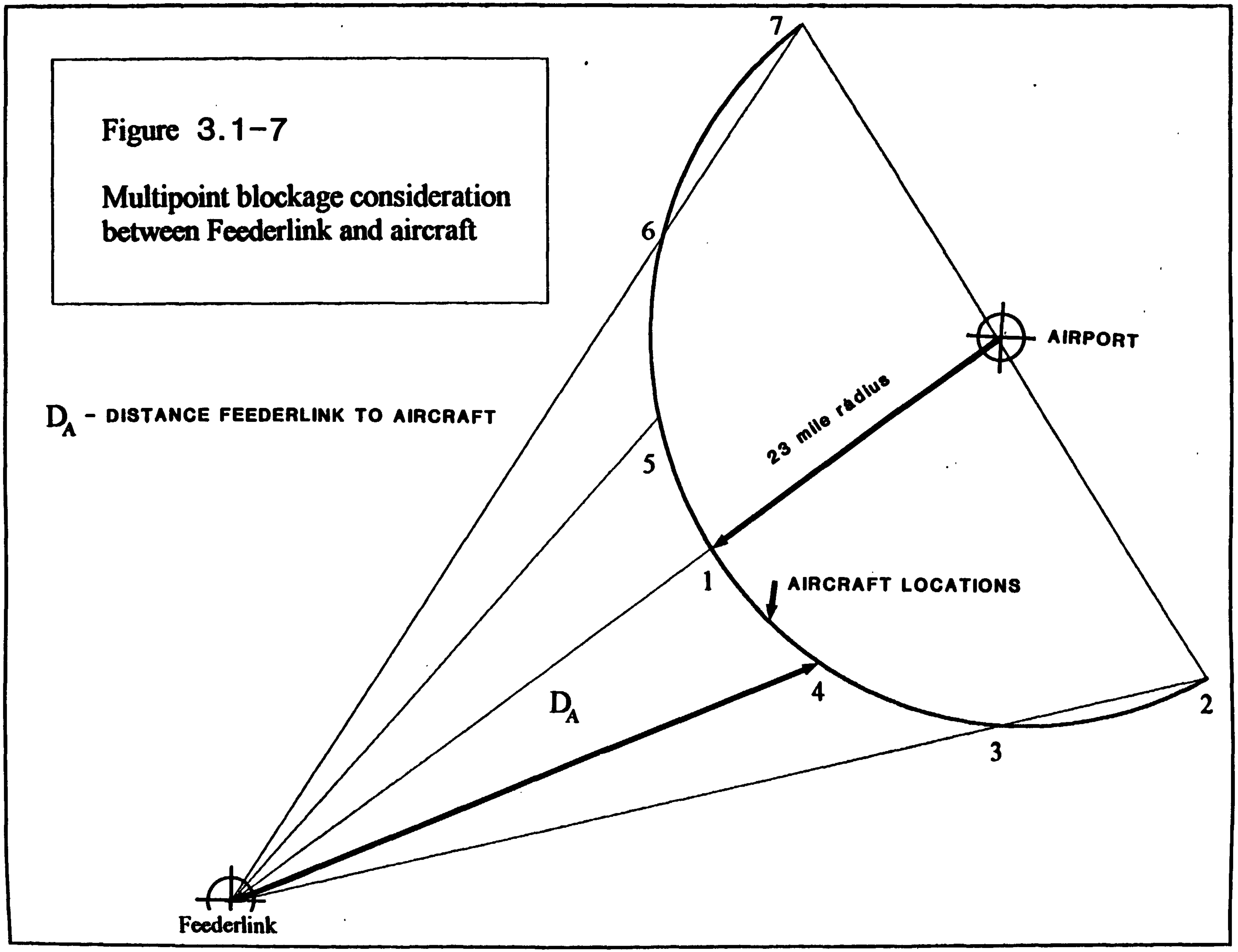


Figure 3.1-7

Multipoint blockage consideration between Feederlink and aircraft

The additional analysis was performed in an attempt to account for the aircrafts' various portions on the paths from Williamsville to the Washington (DCA) airport minus 23 miles on the raduis from the airport. The azimuths from the feederlink, the distances to the points analyzed, the associated over-the-horizon losses are presented in Table 3.1-12.

TABLE 3.1-12
OH Losses for
Various Aircraft Locations for Washington, DC - (DCA)

Name	Azimuth (Degrees)	Distance (miles)	O-H Losses (dB)
DCA 1	83.9	64.77	28.64
DCA 2	98.6	90.79	29.17
DCA 3	101.0	78.85	11.22
DCA 4	93.5	68.83	31.68
DCA 5	74.3	68.82	26.78
DCA 6	69.3	78.83	28.00
DCA 7	69.3	89.53	30.86

The losses to DCA along the 83.9 degrees azimuth to the airport, are listed as 28.64 dB. At different azimuths the losses range from 11.22 dB to 31.68 dB. For the minimum loss of 11.22 and the predicted free space loss of 148.73 dB, an interference level of -154.27 dBW/4 kHz is predicted. This level misses the interference requirements of -165.7 dBW/4 kHz for the 150 kHz receiver by 10.43 dB. Although this (See Table 3.1-11) case was not originally considered an interference case, it must be considered a case at this time. Similar type analysis would need to be undertaken to determine the predicted interference cases for all other airports.

3.2 Summary of Analyses

3.2.1 Full Deployment of MLS Systems

In this section the location for a feederlink station in Williamsville, VA was selected to evaluate terrain blockage effects in reducing interference potential into aircraft landing at the seventy five (75) airports. Table 3.2-1 presents summary of the interference analyses conducted for all of the locations considered. These analyses were based on point-to-point path profiles.

Table 3.2-2 presents an overall summary of the results of the affect of terrain blockage on interference levels to aircraft approaching the seventy five airports.

TABLE 3.2-2

Overall Interference Summary after OH Losses were Considered

Distance to airport (miles)	0-75	76-150	151-175	176-248	249-285
Number of Airports	7	25	12	21	10
Number of aircraft line-of-sight	7	15	1	0	0
Interference Above Objective -165.74 dBW/4 kHz for 150 kHz BW receivers	7	17*	1	0	0
Interference Above Objective -172.04 dBW/4 kHz for 641 kHz BW receiver	7	17*	1	1	0

* Includes Washington DCA which was initially not considered a case.

In addition to terrain blockage, artificial site shielding can reduce the feederlink signals levels into the aircraft. A recommendation of the National Spectrum Managers Association suggested that 15 dB of signal reduction is possible when the ground station antenna is pointing in the direction of the shield. Applying a 15 dB shielding factor to the cases in Table 3.2-2 results in a reduced number of interference cases.

Table 3.2-3 presents an overall summary of the results of terrain blocakge and a 15 dB shielding factor on the interference levels predicted at aircrafts approaching the seventy five airports. The 15 dB shielding factor has been subtracted from the interference levels in Table 3.2-1.

TABLE 3.2-1 AIRPORT SUMMARY

NUMBER ID	AIRPORT	STATE	DISTANCE/ MILES	AZIMUTH	PREDICTED LEVEL (dBW/4 kHz)	O-H LOSSES (dB)	ADJUSTED LEVEL (dBW/4 kHz)
141 DCA	Washington	DC	87.83	83.92	-142.63	28.36	-170.99
148 IAD	Washington	DC	43.54	76.67	-118.96	LOS	-118.96
149 ILG	Wilmington	DE	153.15	67.22	-151.12	49.01	-200.13
299 ADW	Andrews AFB	MD	96.85	86.22	-145.84	31.68	-177.52
300 BWI	Baltimore	MD	111.41	73.32	-146.69	LOS	-146.69
301 CBE	Cumberland	MD	61.42	354.76	-133.51	LOS	-133.51
302 FDK	Frederick	MD	83.53	55.07	-141.63	LOS	-141.63
303 GAI	Gaithersburg	MD	85.74	68.97	-142.16	9.48	-151.64
304 HGR	Hagerstown	MD	83.87	36.06	-141.72	LOS	-141.72
305 MTN	Baltimore	MD	127.48	70.37	-150.63	33.35	-183.98
306 SBY	Salisbury	MD	172.55	97.94	-152.59	47.36	-199.95
376 CLT	Charlotte	NC	273.34	208.26	-157.80	47.86	-205.66
377 EQY	Monroe	NC	277.81	203.62	-157.96	48.66	-206.62
378 OWN	New Olan	NC	267.48	160.00	-157.52	60.68	-218.20
379 FAY	Fayetteville	NC	258.00	182.81	-157.18	59.35	-216.53
380 GSO	Greensboro	NC	194.74	201.62	-154.04	8.90	-162.94
381 OKY	Catawba	NC	255.24	217.02	-157.06	49.87	-206.93
383 INT	Winston Salem	NC	198.57	206.17	-154.25	24.02	-178.27
384 ISO	Kinston	NC	241.49	165.91	-156.44	69.42	-178.27
385 OAJ	Jacksonville	NC	275.05	167.52	-157.52	68.97	-226.49
386 RDU	Raleigh-Durham	NC	197.10	182.09	-154.17	32.66	-186.83
387 RWI	Rocky Mount	NC	202.58	167.77	-154.49	68.34	-222.83
388 SOP	Southern Pine	NC	244.11	189.77	-156.58	55.77	-212.35

TABLE 3.2-1 AIRPORT SUMMARY (cont.)

NUMBER ID	AIRPORT	STATE	DISTANCE/ MILES	AZIMUTH	PREDICTED LEVEL (dBW/4 kHz)	O-H LOSSES (dB)	ADJUSTED LEVEL (dBW/4 kHz)
409 ACY	Atlantic City	NJ	244.93	75.81	-155.67	51.73	-207.40
410 BLM	Belmar-Farmin	NJ	262.37	66.03	-157.36	34.98	-192.38
411 CDN	Caldwell	NJ	275.89	56.15	-157.89	38.25	-196.14
412 EWR	Newark	NJ	274.85	59.04	-157.85	37.76	-195.61
413 MIV	Millville	NJ	197.68	75.98	-154.20	37.92	-192.12
414 MMU	Morristown	NJ	267.19	56.34	-157.55	35.96	-193.51
415 NO7	Robbinsville	NJ	239.81	63.42	-156.38	51.96	-208.34
416 TEB	Teterboro	NJ	285.00	57.65	-158.32	40.21	-198.53
500 ABE	Allentown	PA	216.84	51.23	-155.28	43.81	-199.09
501 AGC	Allengheny County	PA	131.17	329.18	-149.06	22.21	-171.27
502 AOO	Altoona	PA	109.64	9.34	-146.43	LOS	-146.43
503 AVP	Wilkes Barre	PA	237.94	39.68	-156.31	23.46	-179.77
504 BFD	Bradford	PA	212.12	0.23	-155.53	33.40	-188.93
505 BTP	Butler	PA	157.19	334.44	-151.45	30.55	-182.00
506 CXY	Capital City	PA	140.93	42.67	-150.03	LOS	-150.03
507 DUJ	Du Bois	PA	169.50	355.73	-152.39	28.49	-180.88
508 ERI	Erie	PA	244.86	341.37	-156.60	60.62	-217.22
509 FKL	Franklin	PA	193.61	341.14	-153.97	35.17	-189.14
510 IPI	Williamsport	PA	196.32	274.16	-154.12	21.22	-175.34
511 JST	Johnstown	PA	109.99	355.10	-146.49	LOS	-146.49
512 LBE	Latrobe	PA	114.02	339.76	-147.03	LOS	-147.03
513 LNS	Lancaster	PA	158.70	51.99	-151.56	8.80	-160.36
514 MDT	Middletown	PA	143.05	44.45	-150.23	LOS	-150.23

TABLE 3.2-1 AIRPORT SUMMARY (cont.)

NUMBER ID	AIRPORT	STATE	DISTANCE/ MILES	AZIMUTH	PREDICTED LEVEL (dB)	O-H LOSSES (dB)	ADJUSTED LEVEL (dB)
515 MQS	Coatesville	PA	172.58	59.13	-152.59	35.26	-187.85
516 PHL	Philadelphia	PA	199.09	65.62	-154.31	50.71	-205.02
517 PIT	Pittsburgh	PA	147.83	325.86	-150.66	28.63	-179.29
518 PNE	Philadelphia (NE)	PA	216.30	63.28	-155.24	37.32	-192.56
519 PSB	State College	PA	151.79	11.33	-151.00	22.35	-173.35
520.RDG	Reading	PA	183.37	50.77	-153.33	20.86	-174.19
522 3G2	Washington	DC	130.71	318.50	-149.01	24.90	-173.91
592 CHO	Charlottesville	VA	42.17	164.73	-101.45	LOS	-101.45
596 MEP	Manassas	VA	61.62	90.00	-133.86	LOS	-133.86
597 HGR	Waynesboro	VA	83.87	36.06	-141.72	LOS	-141.72
598 HSP	Hot Springs	VA	83.44	230.39	-142.62	LOS	-142.62
599 IAD	Chantilly Dulles	VA	66.42	76.67	-136.07	LOS	-136.07
600 LYH	Lynchburg	VA	101.12	197.22	-145.13	LOS	-145.13
601 DRF	Norfolk	VA	184.50	132.51	-153.40	69.64	-223.04
602 PHF	Newport News	VA	161.55	132.30	-151.92	67.59	-219.51
603 PSK	Dublin	VA	155.68	255.81	-151.32	LOS	-151.32
604 RIC	Richmond	VA	111.48	138.77	-146.68	27.49	-174.37
605 ROA	Roanoke	VA	120.62	217.04	-147.87	52.30	-200.17
606 W10	Manassas	VA	61.62	90.00	-101.45	LOS	-101.45
648 BKW	Buckley	WV	149.05	244.95	-150.76	LOS	-150.76
649 BLT	Bluefield	WV	170.69	235.42	-151.46	39.78	-191.24
650 CKB	Clarksburg	WV	93.20	295.30	-143.73	LOS	-143.73
651 CHW	Charleston	WV	160.93	262.16	-151.74	57.34	-209.08

TABLE 3.2-1 AIRPORT SUMMARY (cont.)

NUMBER ID	AIRPORT	STATE	DISTANCE/ MILES	AZIMUTH	PREDICTED LEVEL (dBW/4 kHz)	O-H LOSSES (dB)	ADJUSTED LEVEL (dBW/4 kHz)
652 HLG	Wheeling	WV	145.95	313.80	-150.49	30.59	-181.08
653 DTS	Huntington	WV	212.77	264.48	-155.05	65.67	-210.72
654 LWB	Lewisburg	WV	112.14	238.18	-148.13	LOS	-148.13
655 MGW	Morgantown	WV	92.47	313.40	-144.57	LOS	-144.57
656 MRB	Martinsburg	WV	58.86	37.68	-131.86	LOS	-131.86
657 PKB	Parkersburg	WV	155.60	286.74	-151.32	52.37	-203.69

TABLE 3.2-3 Overall Interference Summary after OH Losses and 15 dB Shielding Factor were Considered					
Distance (miles	0-75	76-150	151-175	176-248	249-285
Number of Airports	7	25	12	21	10
Interference Above Objective -165.74 dBW/4 kHz for 150 kHz BW receiver	7	4	0	0	0
Interference Above Objective -172.04 dBW/4 kHz for 641 kHz BW receiver	7	12	0	0	0

The following is an expansion on the results presented in Tables 3.2-1, 3.2-2 and 3.2-3.

Airports within 0-75 miles

As can be seen in the Table 3.2-1, 100 percent of the airports within 75 miles of the feederlink site were line-of-sight and are potential interference cases even though an artificial site shielding factor of 15 dB was applied. For the airports within 75 miles Chantilly Dulles had the lowest predicted interference level of -145.07 dBw/4 kHz (Table 3.2-1). A 15 dB shield reduces this level to -160.07 dB, which is 5.67 dB from the objective.

Airports within 76-150 miles

Twenty five airports were located between 76 to 150 miles from the feederlink station. There were 15 locations where the aircraft locations were line-of-sight (LOS) from the feederlink location. The distance to the aircraft LOS location ranged from 60.44 miles (HSP) to 126.05 miles. There were 17 locations where both the -165.74 dBW/4 kHz and the -172.04 dBW/4 kHz interference objectives were exceeded when only terrain blockage was considered (Table 3.2-2).

When a shielding factor of 15 dB was applied the potential interference cases is reduced to 4 cases for the -165.74 dBW/4 kHz objective and 12 cases for the -172.04 dBW/4 kHz objective (Table 3.2-2).

Airports within 151-175 miles

There were 12 airports located between 151 to 175 miles from the feederlink station. There was 1 location where the aircraft was line-of-sight (LOS) from the feederlink site. The distance to the LOS location was 132.68 miles (PSK). This was the only location where the interference objective of -165.74 dBW/4 kHz was not satisfied. When a site shielding factor of 15 dB is applied the potential interference case is resolved.

Airports within 176-248 miles

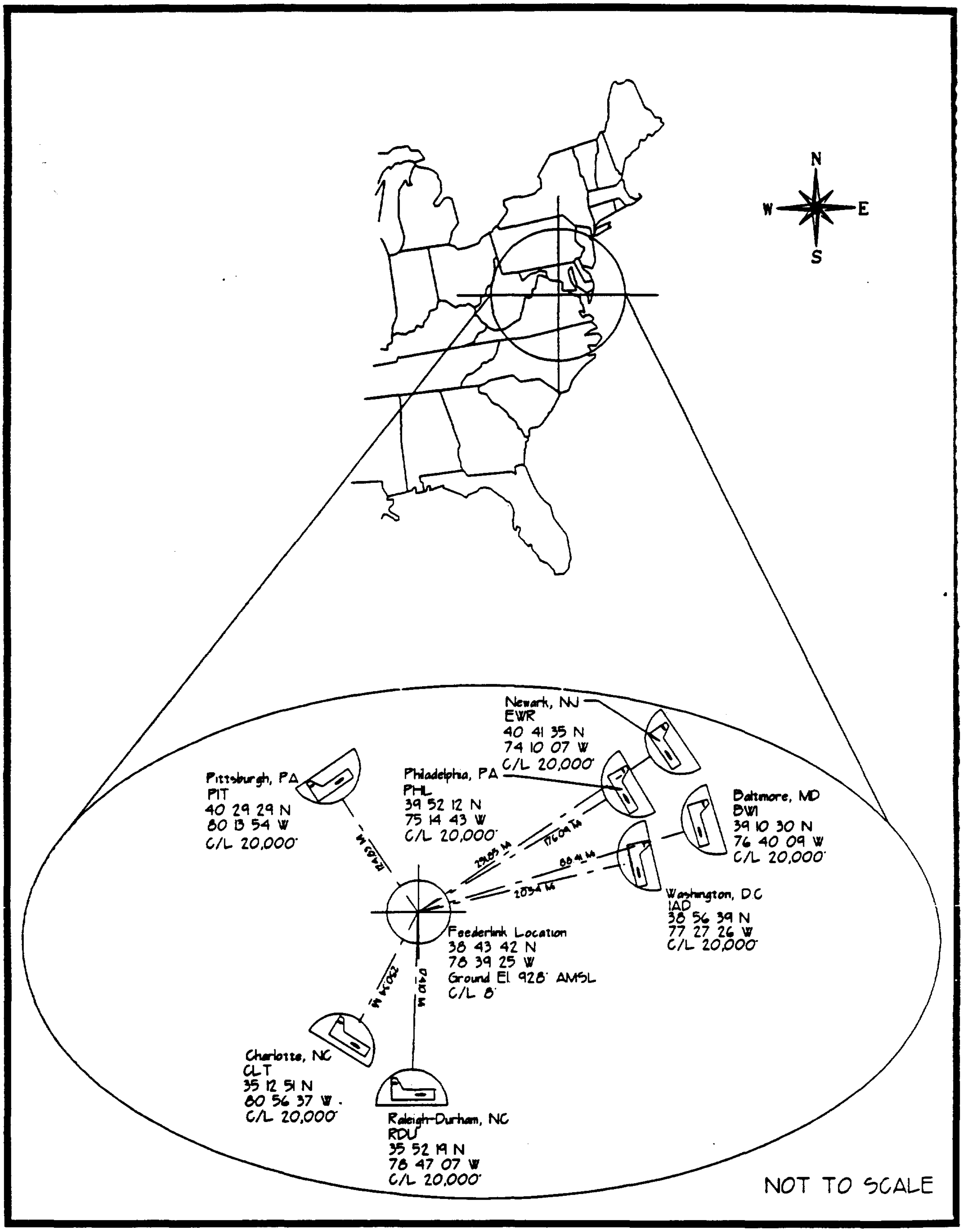
There were 21 airports located between 176 to 248 miles from the feederlink station. There were no locations where the aircraft was line-of-sight (LOS) from the feederlink site. There was 1 location where the interference objective of -172.04 dBW/4 kHz was not satisfied (Table 3.2-2). When a site shielding factor of 15 dB is applied the potential interference case is resolved (Table 3.2-3).

Airports within 249-285 miles

There were 10 airport located between 249 to 285 miles from the feederlink station. There were no locations where the aircraft were line-of-sight (LOS) from the feederlink site. There were no locations where the interference objectives were not satisfied (Table 3.2-2).

3.2.2 Reduced Deployment of MLS Systems

A reduced deployment of the MLS system in the area analyzed reduces the number of potential interference conflicts. The reduced deployment scenario assumes only seven prominent airports instead of the seventy five (75) analyzed earlier. The deployment of the MLS systems to the airports shown in Figure 3.2.2-1 is analyzed in this section. Aircraft approaching these airports would be subjected to the predicted interference power levels presented in Table 3.2.2-1. The results presented are for a single path profile which would need to be expanded on, when actual sites are selected.



Airport Systems Sketch

COMSEARCH

FIGURE 3.2.2-1 REDUCED MLS DEPLOYMENT

TABLE 3.2.2-1 MLS Reduced Deployment Predicted Interference Power Levels into Aircraft for a Reduced MLS Deployment		
Airport	Predicted Interference Level dBW/4 kHz	Interference Objective (1) dBW/4 kHz
Newark, NJ (EWR)	-204.61	-165.74
Philadelphia, PA (PHL)	-214.02	-165.74
Baltimore, MD (BWI)	-155.69	-165.74
Washington, DC (IAD)	-111.00	-165.74
Raleigh Durham, NC (RDU)	-195.83	-165.74
Charlotte, NC (CLT)	-214.66	-165.74
Pittsburgh, PA (PIT)	-188.29	-165.74

Note (1) Objective for receiver bandwidth of 150 kHz.

Based on Table 3.2.2-1 the only two airports where interference levels exceed the interference objective are Washington, DC (IAD) and Baltimore, MD (BWI). This clearly shows that a limited deployment of MLS systems could result in an enhanced feasibility of deploying a Globalstar feederlink in congested MLS environments.

3.3 Summary of Results

For the Williamsville site and full MLS deployment, 100 percent of all airports within 75 miles were line-of-sight. While 68.8 percent of all airports within 150 miles were line-of-sight. In addition 75.0 percent of all studied airports within 150 miles did not satisfy the interference objective for both 150 kHz and 641 kHz bandwidth. There was only one airport at distances greater than 150 miles that appears to be a problem.

Additional analysis was performed to attempt to account for variable aircraft locations on the paths from Williamsville to the Washington, DC (DCA) airport. This analysis indicated that the Washington DCA site had insufficient blockage on at least one of the seven paths profiled and needs to be considered an interference conflict.

The reduced MLS deployment scenario shows that only two out of seven or 21.6 percent of the airports did not meet the interference objective.

In a congested area environment after terrain blockage and man made site shielding are considered, frequency restrictions will likely need to be imposed on the feederlink transmission for either a complete deployment of MLS systems or a reduced deployment. A reduced deployment will likely result in fewer frequency restrictions, dependent on the required number of frequencies per airport.

4.0 Conclusions and Recommendations

4.1 Conclusions

The conclusions are based on a feederlink gateway located in Williamsville, Virginia and deploying frequencies in the 5000 MHz to 5250 MHz band. The total number of analyzed airports were 75 located in the states of Virginia, North Carolina, West Virginia, Maryland, Delaware, New Jersey, Pennsylvania, and the District of Columbia. The analyzed area is considered very congested. Furthermore, the 75 airports are a subset of the 662 projected implementation of the MLS in the US mainland, Alaska, Hawaii, Puerto Rico, and the US Virgin Islands.

The study indicates that sharing the frequency spectrum between MLS and a Globalstar feederlink gateway appears feasible. Given that the location of the gateway is in a very congested area, restricted use on some gateway frequencies, or additional interference reduction techniques beyond terrain and artificial shielding need to be deployed. Based on an interference objective of -165.74 dBW/4 kHz (for a 150 kHz receiver), and the analyzed terrain, the results showed that MLS frequencies at 25 airports should be further avoided. Applying a 15 dB artificial shielding factor in addition to the terrain attributed losses, frequencies at 11 (19) airports need to be further restricted for a 150 kHz (641 kHz) receivers.

Analyses for reduced MLS deployment at a total of seven (7) candidate airports showed only 2 airports that require MLS frequencies restrictions (for both 150 and 641 kHz receivers). The primary airports to receive MLS are believed to be only 100 from the projected 662 airports. Only a total of seven (7) airports out of the total of 75 analyzed earlier were primary candidates.

To further enhance the spectrum sharing possibility with MLS locations, sites in less congested areas than the site analyzed in this report should be considered for the Globalstar feederlink locations. It is anticipated that sites in the less congested areas would place only minimal frequency restrictions on the operating frequencies at any Globalstar feederlink location.

4.2 Recommendations

The findings of this study indicate that the location of Globalstar feederlinks can be further enhanced since a worst case interference analysis was performed. It is recommended that consideration be given to the following items to ease the selection of feederlink sites:

- Develop a frequency plan that makes sharing of the frequency spectrum between the aeronautical services and the mobile satellite services more efficient.

* Evaluate the maximum coupling duration between an aircraft and feederlink antennas to determine if the interference objective can be reduced.

* Evaluate the impact of the Globalstar spread spectrum signal into any other systems planned for the 5000 - 5250 MHz spectrum.

* Produce more refined interference objectives for sharing between spread spectrum and the MLS deployed modulation. A refined interference objective is needed for both co-channel and non co-channel interference. Bench testing of the two systems could provide the most conclusive results.

REFERENCES

[1] US Department of Transportation, Federal Aviation Administration Specification NAS System Specification Volume I, Functional and Performance Requirements for the National Airports System General, Appendix II NAS Architecture Table 20.6, 2.7.

[2] Airborne Microwave Landing System, Characteristic 727-1, Published August 27, 1987, Sections 3.1.3 and 3.1.5.

[3] International Civil Aviation Organization (ICAO) (Annex 10) Attachment G to Part I. - Information and Material for Guidance in the Application of the MLS Standards and Recommended Practices in Annex 10

ATTACHMENT 4

Interference Assessment of MSS Gateway Uplink Transmissions Relative to MLS Airborne Users

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Interference Assessment of MSS Gateway Uplink Transmissions Relative to MLS Airborne Users

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Interference Assessment of MSS Gateway Uplink Transmissions Relative to MLS Airborne Users

Executive Summary

The proposed uplink frequency band for MSS gateway operations, 5000 - 5250 MHz, overlaps the existing frequency allocation for the Microwave Landing System (MLS). As a result, it is necessary to evaluate the potential for coexistance and frequency coordination within the band. This report evaluates the levels of radio frequency interference (RFI) generated by MSS gateway operations in the 5000 - 5250 MHz band in relation to MLS specifications, and demonstrates that coexistance and frequency coordination is feasible and easily achieved. Complete protection of MLS operations can be assured through standard and straightforward frequency management techniques.

Noting that Globalstar will field roughly 10 gateway stations in the United States, we recommend that coordination be performed on a site-by-site basis. Techniques that can be used to assure complete protection of MLS operations include:

a) physical separation between MSS gateways and MLS ground sites;

b) terrain masking;

c) RF fences engineered and constructed near the MSS gateway, to specifically enhance signal blockage in the direction of MLS service volumes;

d) antenna stops in the MSS gateway antenna that preclude antenna boresight aiming in selected azimuth/elevation sectors associated with MLS service volumes inside the radio horizon; and

e) software control of MSS frequency assignments such that specific frequencies surrounding MLS channel assignments in the neighborhood of the MSS gateway are avoided when the gateway antenna boresight is within predefined azimuth/elevation sectors.

Section 7 illustrates one candidate coordination scenario which combines physical separation, an RF fence and physical antenna stops in the mechanical assembly of the MSS gateway antenna. These physical mitigation techniques are shown to guarantee full protection to MLS operations. A wide variety of alternatives may be configured, dependent on the characteristics of specific MSS gateway locations and their geometries relative to MLS ground sites located within a range of roughly 200 nmi.

The recent MLS program decisions by the FAA, effectively cancelling the MLS program except for those systems already built and in the inventory, imply that the number of MLS ground sites will be extremely limited within the United States. Current planning indicates 19 ground sites within the lower 48 states and 11 in Alaska. The situation in Europe and elsewhere is not clear; however, a likely scenario is for the worldwide aviation community to shift from MLS toward satellite navigation systems. This would parallel the evolution within the United States. Therefore, worldwide coordination of MSS gateway operations should be straightforward and easily achieved.

Section 1
Background

The proposed Globalstar MSS gateway station uplink frequency band of 5000 -5250 MHz overlaps with the current allocation for the Microwave Landing System (MLS). While the FAA has recently announced cancellation of the MLS procurement, some pre-existing MLS equipment may be fielded within the United States over the next several years. Thirty systems currently exist in the inventory; these could equip up to thirty airports. As a result, an interference assessment and sharing strategy must be investigated. Furthermore, the situation in Europe and other overseas environments relative to MLS is not clear. An interference assessment is useful to understand the possible sharing strategies for overseas environments.

This interference assessment is based on Microwave Landing System (MLS) background data provided in Appendix A. The MSS gateway transmitter power density at the transmit antenna input port is assumed to be -16 dBW/4kHz/polarization over the active portions of the 5000 - 5250 MHz band. The active portions of the band constitute eight (8) dual-polarization subbands, each 16.5 MHz wide. Each subband/polarization pair represents the uplink feeder for a single spot beam downlink for the L-band users. Dual polarization reuse provides capacity for 16 spot beams, and necessary guardbands, within the available 250 MHz allocation.

Two separate assessments must be performed: (1) an out-of-band assessment that examines the impact of MSS gateway transmissions in the 5000 - 5250 MHz band exclusive of the MLS band; and (2) an in-band assessment that examines the impact of MSS gateway transmissions in the 5031 - 5091 MHz MLS band referenced in ARINC Characteristic 727-1. The out-of-band assessment is less constraining for the MSS gateway, and places a lower bound on keepout distance and coordination complexity. It will be addressed first (in Section 3 below). The in-band assessment is more constraining, and implies additional requirements in terms of the keepout distance, excess path attenuation, or active avoidance strategies such as frequency avoidance based on MSS antenna boresight azimuth and elevation angles relative to MLS service volumes in the coordination region.

Section 2
Worst-Case MSS/MLS Geometry

Exhibit 1 illustrates an elevation view of the geometry for MSS gateway transmissions relative to MLS ground sites and service volumes. The MLS operating range is 20 nmi and the MLS service ceiling is 20,000 feet (6096 meters). For simplicity, the total MLS service volume is taken to be a cylinder with these dimensions. Appendix A provides a more complete description of the MLS service volume, which is wholly contained within this surface.

The MSS gateway must be situated a safe distance from the MLS ground site and service volume. Essentially, the so-called user keepout distance, r_u, must be designed to ensure sufficient space loss and antenna offpointing loss to preserve reasonable operating margins in the airborne MLS receiving equipment. As will be seen by the RFI analysis below, the main lobe of the MSS gateway's antenna pattern should never intersect the MLS service volume. Note that the distance to the MLS ground site, r_g, is 20 nmi greater than r_u.

The MSS gateway will generate a highly directive antenna beam toward a spacecraft in orbit. The minimum elevation angle for access is 10 degrees off the horizon, and the null-to-null beamwidth is approximately 1 degree. The offpointing angle to an MLS user situated in the worst-case point within the service volume is therefore $(10-\theta)$ degrees, where, for a flat earth, $\theta = \arctan(6096/r_u)$

Assumptions

1. MLS user at maximum range and altitude from MLS

2. MLS user at worst case location relative to MSS gateway uplink signal

3. MSS gateway uplink at minimum operational elevation angle

Analysis

r_u = Keepout range relative to MLS user

r_g = Keepout range relative to MLS ground site

$= r_u + 20$ n.mi

G_r = MSS gateway antenna gain toward MLS user

$$= 32 - 25 \text{ Log } (10 - \theta);\ \theta = \arctan\left(\frac{6096}{r_u}\right)$$

L_s = space loss from MSS gateway to MLS user

$$= 20 \log\left(\frac{4\pi\ r_u}{\lambda}\right);\ \lambda \approx 6 \text{ cm}$$

3

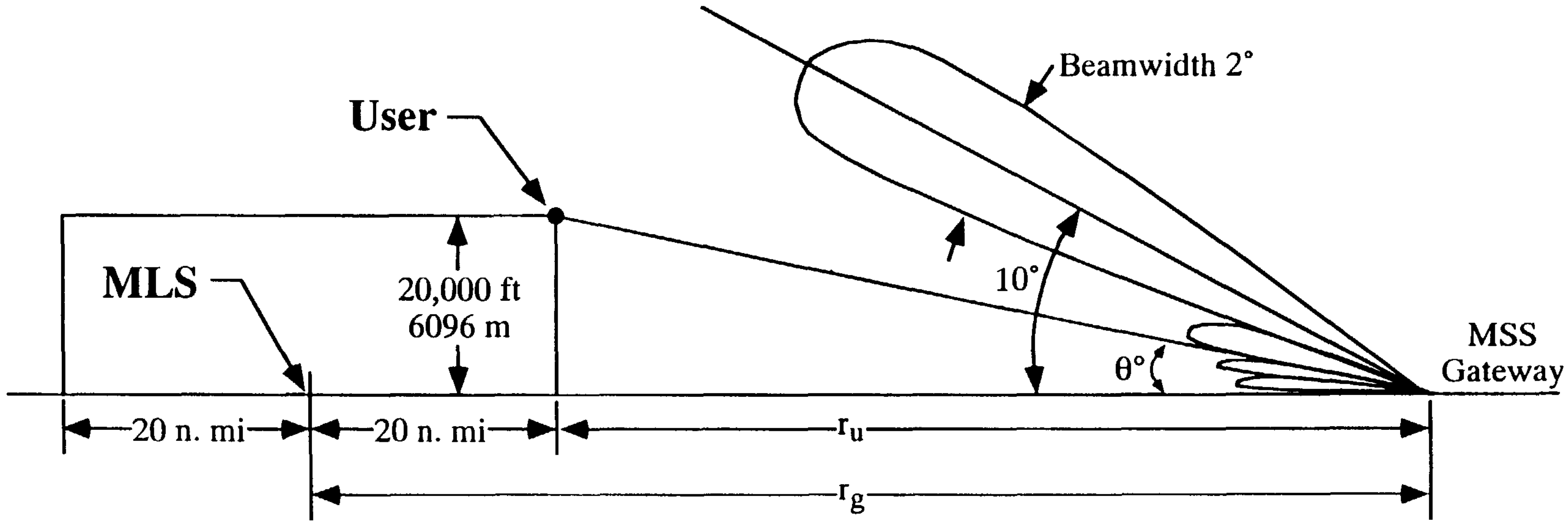

Exhibit 1: Worst-case RFI geometry for MSS gateway/MLS analysis